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OPEN-WATER PERFORMANCE OF TANDEM PROPELLERS.(U)

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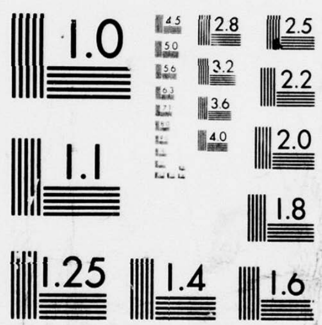

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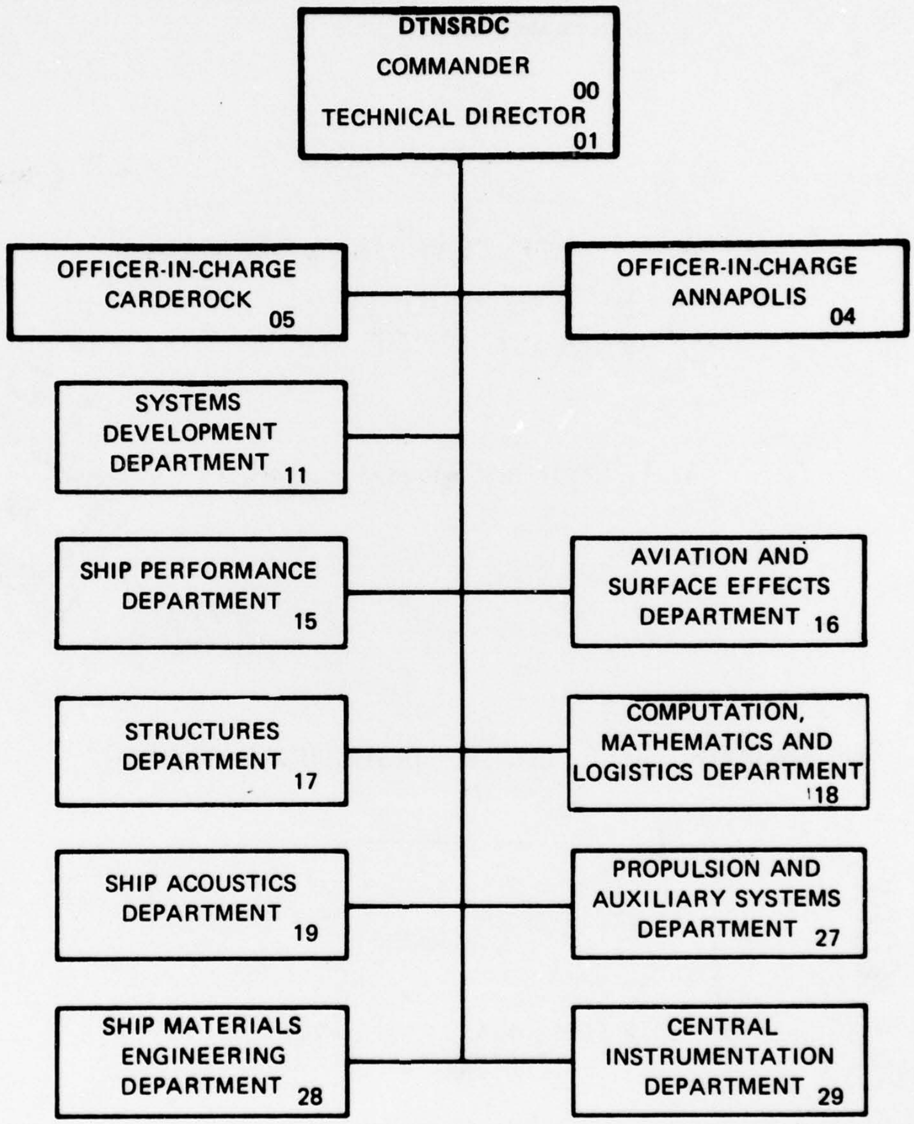

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Tandem propellers, defined as two propellers coaxially mounted to the same shaft, were characterized in open water. The motivation for this work was to determine if the reduced loading per propeller would improve efficiency. Other potential gains such as reduced vibration and decreased cavitation are to be studied later. The experiments were performed at two angular positions and only one axial spacing for direct comparison to a standard

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parent propeller. The performance shows that improved efficiency is obtainable with tandem propellers. The results also show that changes in performance occur with different angular positions of the propellers. Additional experiments are recommended.

INTRODUCTION

The tandem propellers described in this report consist of two propellers operating one behind the other, on the same shaft with the same rotational speed and direction of rotation. The proper design of such propellers requires special consideration of the distance between forward and after propellers, relative angular position of the blades of the two propellers, and an accurate prediction of the interaction between the two propellers in order that the prescribed loading may be attained. Drawings of one set of tandem propellers (4148 and 4149) designed at the Naval Ship Research and Development Center (NSRDC) are shown in Figures 1 and 2.

The concept of tandem propellers is being explored in an attempt to determine if greater propeller efficiency (η_0) can be obtained (than for a single propeller) while maintaining the same thrust coefficient (K_T). Also, the possibilities exist for reducing blade cavitation by increasing the effective total blade area and/or reducing the loading on each propeller. Other advantages are potential reductions in propeller induced hull and machinery vibrations. Preliminary (unreported) experiments with propellers 4148 and 4149 showed a greater efficiency than was predicted, thus meriting further investigation into their capabilities. This report presents an open water evaluation of these propellers, and compares their performance to the parent propeller, NSRDC propeller 4118.

ADMINISTRATIVE INFORMATION

This work was sponsored by Naval Ship Research and Development Center (NSRDC), funded by IR,IED, and performed under Work Unit Number 1528-024.

PROCEDURE

Open water experiments were conducted at NSRDC on Propellers 4148 and 4149 in April 1973, utilizing Carriage I, the propeller boat, and a 100 inch-pound transmission type dynamometer for measuring propeller thrust and torque (Figure 3). The propellers were run at a speed of advance (V_A) varying from 3.0 to 12.0 ft/sec and a rotational speed (N) from 7.0 to 11.0 revolutions per second permitting operation at Reynolds numbers R_n from 4.1×10^5 to 6.7×10^5.

Since it was probable that various angular positions of the forward blades with respect to the aft blades would have an effect on the performance of the unit, the propellers were tested at two blade settings: the design setting (Setting 4), where the blades of the aft propellers were centered between those of the forward propeller (Figure 4), and Setting 1, where the blades of the two propellers were in line with each other (Figure 5).

RESULTS

The comparison of the open water curves for Tandem Propellers 4148 and 4149 and parent Propeller 4118 are shown in Figure 6. Tabulated open water data for the tandem propellers at both blade settings are presented in Table 1. Both the tandem propellers and the parent propeller were

designed for uniform inflow for a K_T near 0.15 at a speed coefficient, J, of 0.833. It can be seen from the performance characteristics shown in Table 2 that at the design angular spacing, the tandem propellers produced a higher thrust and torque than designed for but percentage wise were as near design as was the parent propeller. Overall, a peak efficiency of 75 percent is observed at a J of 0.94 for setting 1 (tandem) and an efficiency of .737 at a J of 0.91 for setting 4 (tandem) while the peak efficiency of propeller 4118 was 72 percent at a J = 0.94.

CONCLUSIONS AND RECOMMENDATIONS

Based on the design performance characteristics the tandem propellers appear to be a suitable substitute for the parent propeller. Further studies are recommended for tandem propellers to determine which aspects of the design of such propellers, such as relative angular and axial position of the individual propellers, have the greatest affect on the overall performance characteristics of the unit. Also, since one of the potential gains of tandem propellers is to reduce cavitation, cavitation tests for the existing propellers should be performed and compared with cavitation tests of the partent propeller.

SETTING 1				SETTING 4 (DESIGN)			
J	K_T	$10K_Q$	η_o	J	K_T	$10K_Q$	η_o
.050	.451	.632	.057	.050	.468	.702	.053
.100	.434	.618	.112	.100	.454	[illegible]	.106
.150	.417	.603	.165	.150	.438	[illegible]	.157
.200	.401	.588	.217	.200	.422	[illegible]	.208
.250	.384	.572	.267	.250	.404	.622	.259
.300	.368	.555	.316	.300	.386	.599	.308
.350	.351	.538	.363	.350	.367	.574	.356
.400	.334	.520	.409	.400	.347	.548	.404
.450	.316	.501	.453	.450	.327	.521	.449
.500	.299	.480	.495	.500	.305	.492	.494
.550	.281	.458	.536	.550	.284	.463	.536
.600	.262	.435	.575	.600	.262	.433	.577
.650	.243	.410	.612	.650	.239	.402	.615
.700	.223	.384	.646	.700	.216	.370	.650
.750	.202	.355	.678	.750	.193	.337	.682
.800	.180	.325	.706	.800	.169	.304	.708
.850	.158	.293	.729	.850	.145	.270	.727
.900	.134	.258	.744	.900	.121	.236	.737
.950	.110	.222	.749	.950	.097	.201	.733
1.000	.084	.183	.733	1.000	.073	.165	.706
1.050	.057	.141	.679	1.050	.049	.130	.637
1.100	.029	.097	.528	1.100	.026	.094	.480
1.150	0.000	.050	0.000	1.150	.002	.058	.068
				1.155	0.000	.054	0.000

Table 1 - Faired Values of Open Water Data for Two Settings of Propellers 4148-49

Propeller Number	Coefficient	Design	Open Water	Pct. Difference
4118	J	0.833	0.833	0
	K_T	0.154	0.150	-3
	$10K_Q$	0.290	0.285	-2
	η_o	0.706	0.698	-1
4148-49	J		0.833	
Setting 1	K_T		0.166	
	$10K_Q$		0.305	
	η_o		0.723	
4148-49	J	0.833	0.833	0
Setting 4	K_T	0.150	0.154	+3
	$10K_Q$	0.275	0.281	+2
	η_o	0.723	0.722	0

Table 2 - Open Water Performance at Design Advance Speed

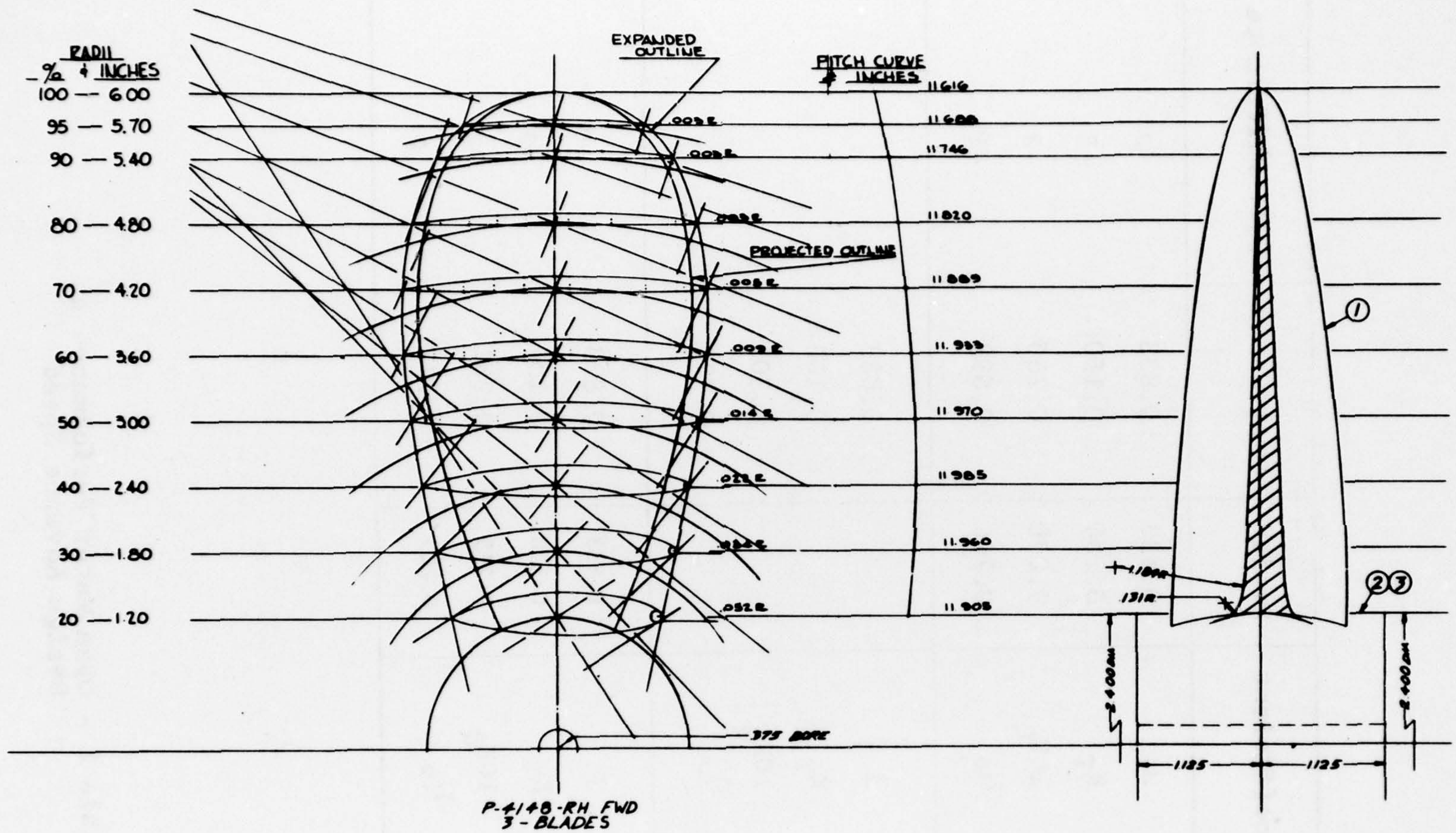

Figure 1 - Drawing of Propeller 4148 (Fwd)

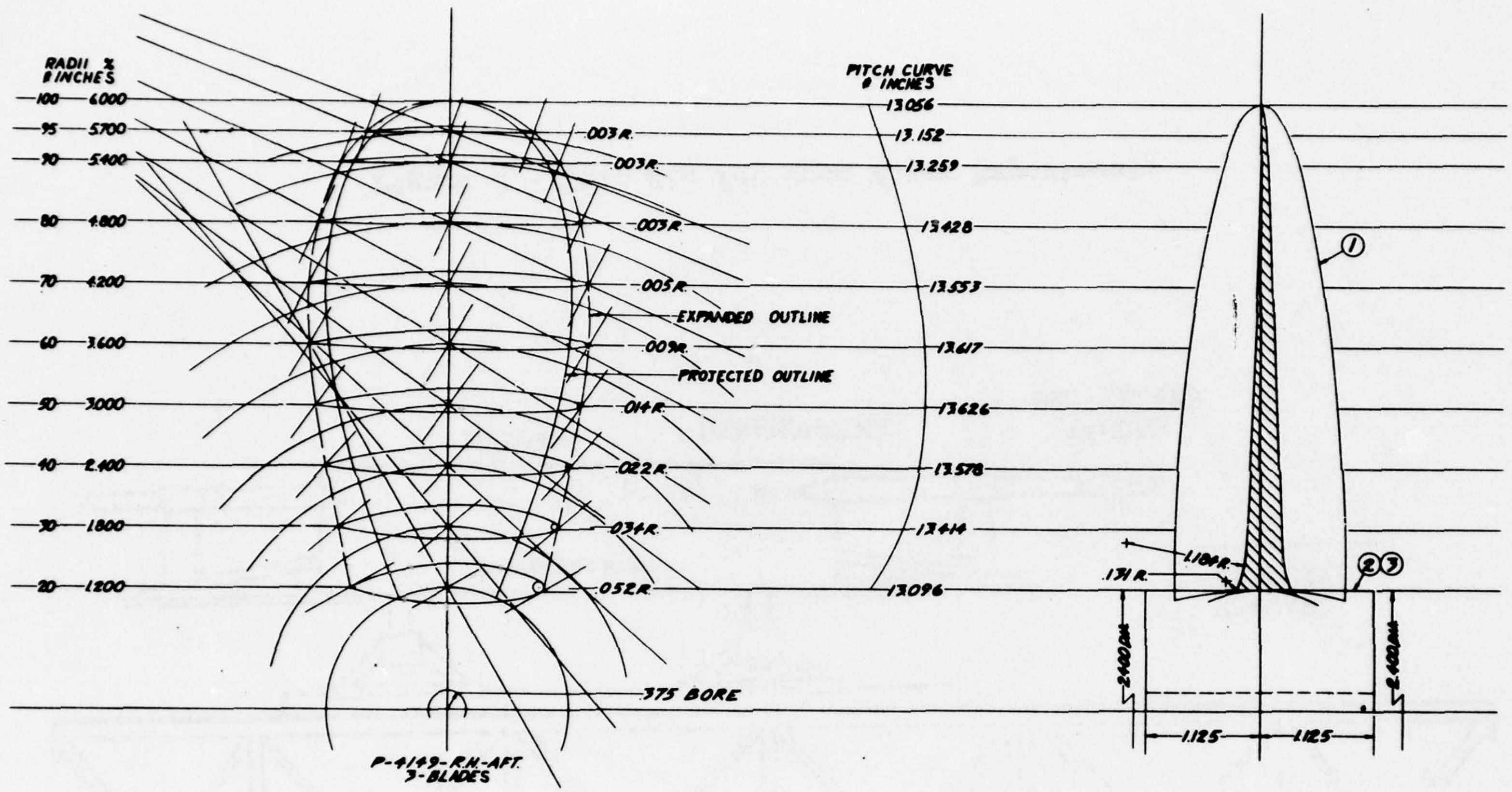

Figure 2 - Drawing of Propeller 4149 (Aft)

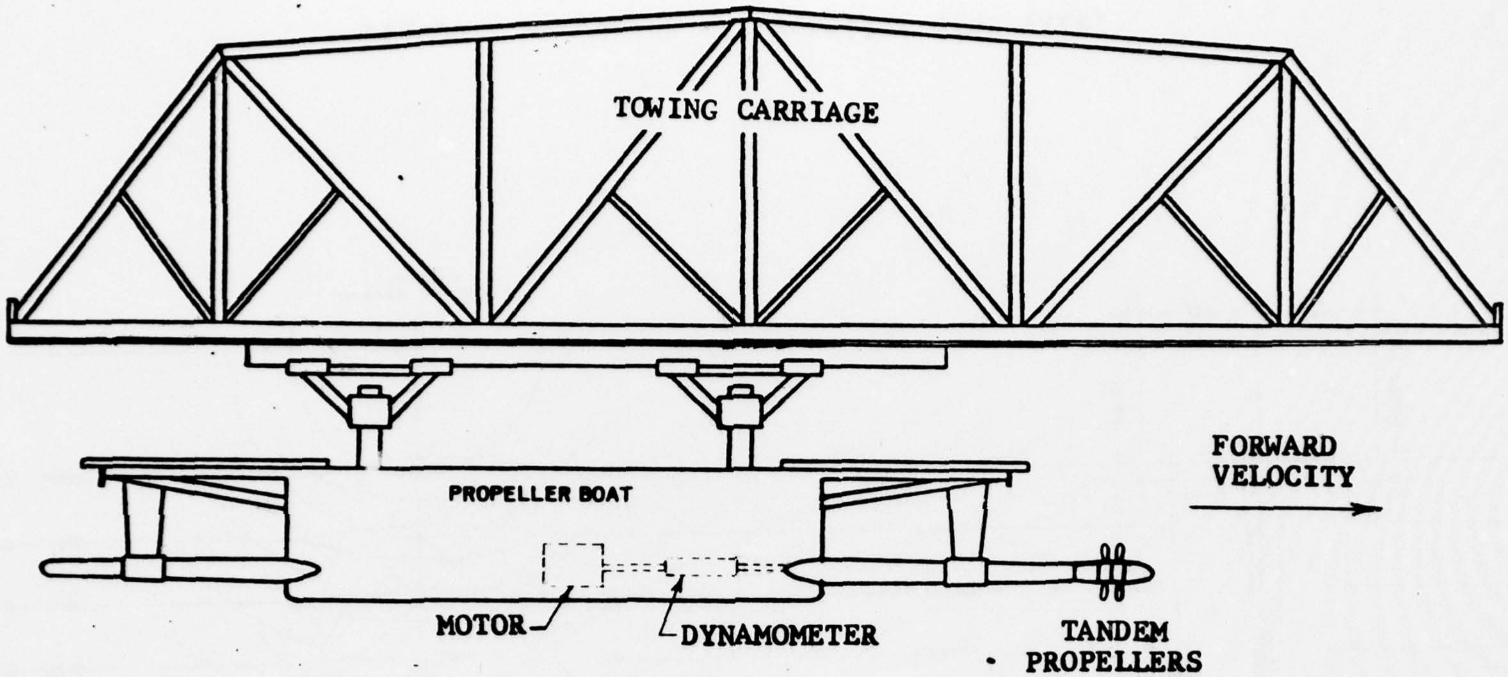

Figure 3 - Test Rig for Open Water Experiments

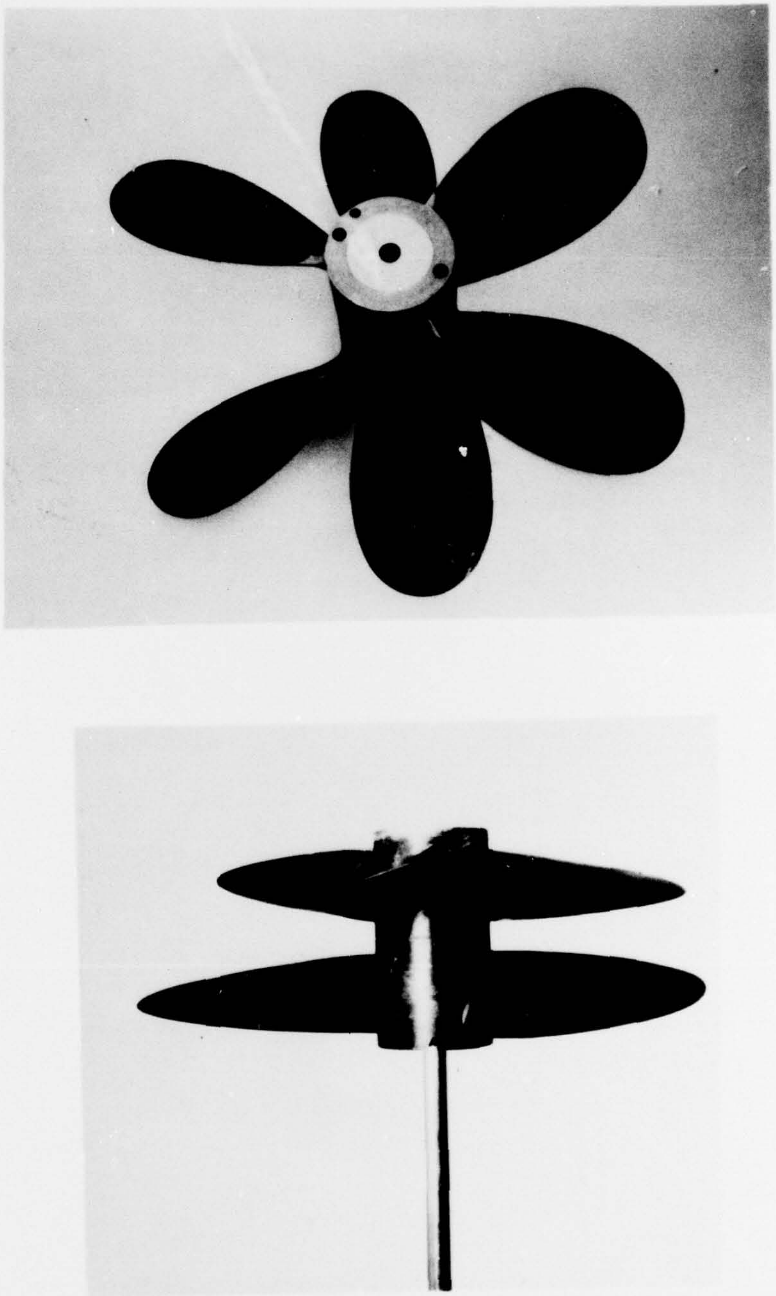

Figure 4 - Photographs of Propellers 4148-49 at Setting 4 (Design Setting)

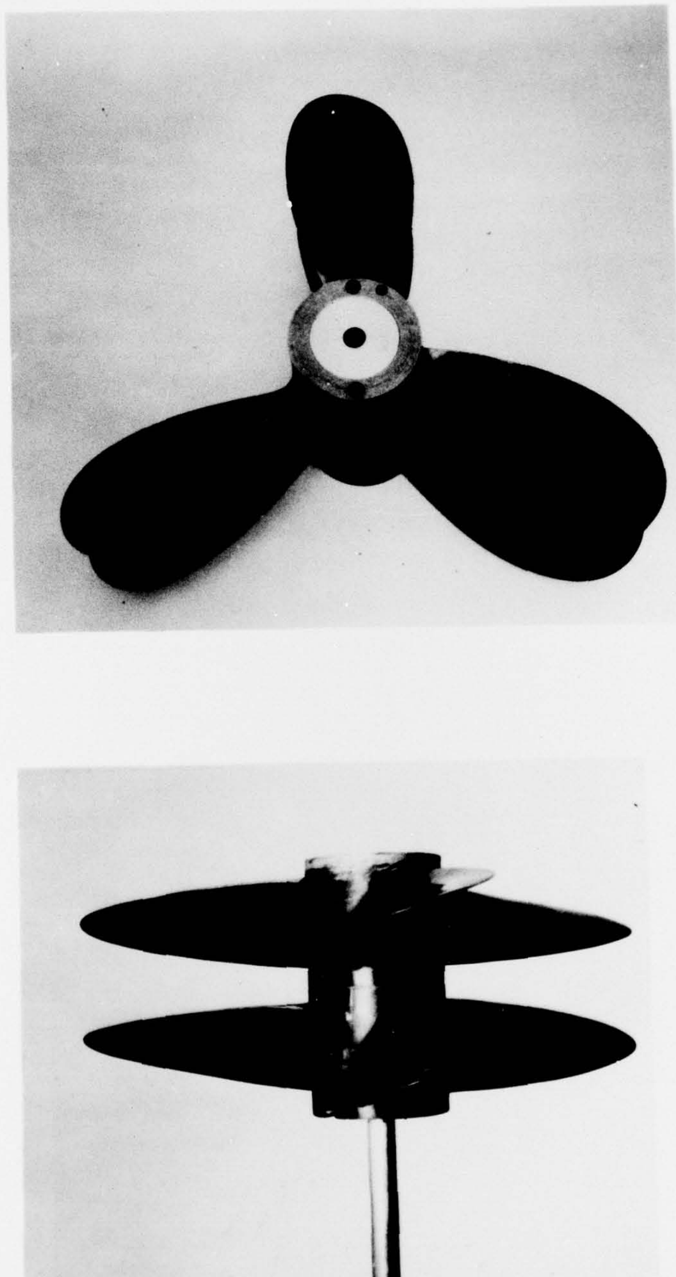

Figure 5 - Photographs of Propellers 4148-49 at Setting 1

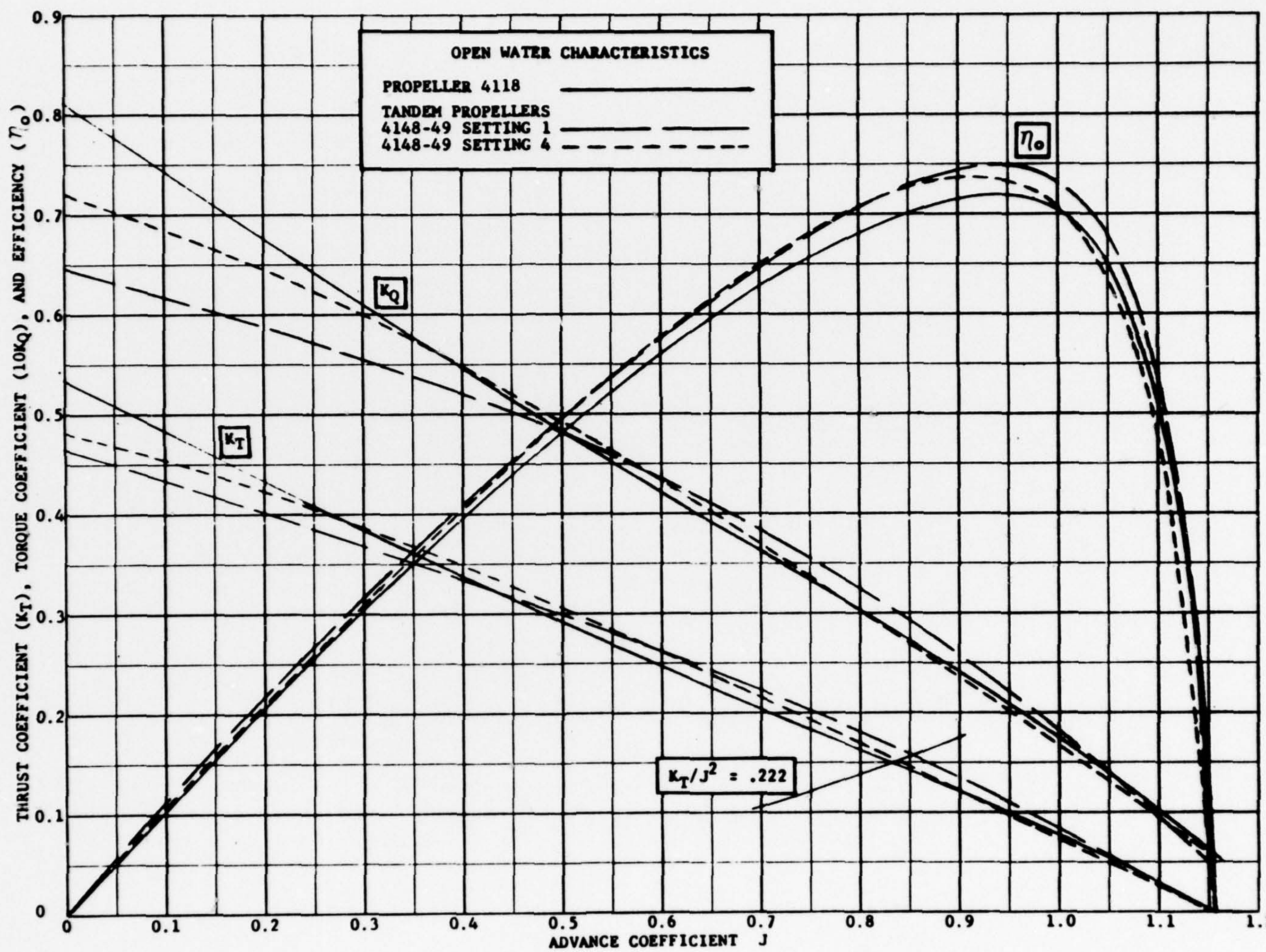

Figure 6 - Open Water Characteristics for Propellers 4148-49 and 4118

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